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Research Article

# Pulmonary Artery Banding in Developing Countries: Is it Still Relevant?

**Zahira Zouizra, Gaël Biaou*, Yassine Boukaidi, Soukaina Benbakh, Salwa El Karimi and Drissi Boumzebra**

*Cardiovascular Surgery Unit, Mohammed VI Teaching Hospital, Marrakech, Morocco*

***Corresponding Author**: Gaël Biaou, Cardiovascular Surgery Unit, Mohammed VI Teaching Hospital, Marrakech, Morocco.

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## Abstract

**Objective:** Pulmonary Artery banding (PAB) is a palliative surgical procedure still used as a progressive approach to treat newborns and infants with congenital heart defects (CHD) not considered for feasible immediate complete repair. Our policy is not to perform complete repair procedures on many CHD patients weighing less than 6 kg. We report a single center retrospective experience from treating patients with CHD using this technique.

**Methods:** We collected data of 165 patients who underwent pulmonary artery banding with invasive hemodynamic study at the Department of Cardiovascular Surgery, Mohamed VI Teaching Hospital-Marrakech Morocco, between January 2006 and June 2016.

**Results:** The mean age was 9.4 months and the mean weight was 5.4 kg. The main indications for PAB were complete atrioventricular canal (44.2%) and ventricular septal defect (36.9%). PAB was performed through mini-sternotomy exposure in 92% procedures. Intraoperative hemodynamic study was performed for all patients before and after banding. The mean pulmonary arterial pressure was lowered by 34.7% and systemic arterial pressure increased by 18%. The mean postoperative gradient across the banding, measured by trans-thoracic ultrasound cardiography was 33.9 mmHg. The mean ICU stay was 4.5 days. 17% of patients had postoperative complications. The in-hospital mortality rate was 15.7%. Thirty six percent had complete repair in our unit after PAB and 3% of them had pulmonary artery reconstruction.

**Conclusion:** Invasive monitoring of PAB ensures its effectiveness, which was proven by post-operative ultrasound study. Patients need close follow-up to keep watch over complications and the effectiveness of the banding.

***Keywords:*** *Pulmonary Artery Banding (PAB); Congenital Heart Defects (CHD)*

## Introduction

Muller and Dammann described pulmonary artery banding (PAB) for palliative care of congenital heart disease (CHD) with pulmonary hypertension (PAH) secondary to increased pulmonary blood flow in 1952, a time when intra cardiac repair was virtually nonexistent [1]. Today this operation is still used in developing countries as a progressive approach to treat newborns and infants with congenital heart defects (CHD) not conducive for immediate complete repair. Currently, early primary repair is the first choice treatment for congenital cardiac defects [2,3]. We report a single center retrospective experience from treating patients with CHD using this technique.

## Objective of the Study

The objective of this study was to report the epidemiologic, clinical profiles, indications, morbi-mortality and postoperative outcome of patients who underwent PA banding in our unit and to analyze if PA banding still plays an important role in the treatment of congenital heart disease.

## Materials and Methods

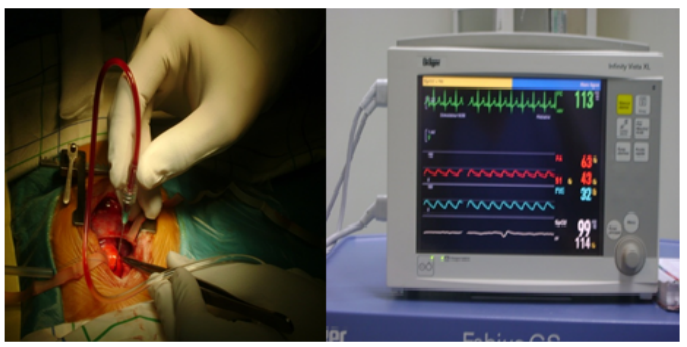
One hundred sixty five patients (165 Pts) who underwent pulmonary artery banding with invasive hemodynamic study at the Department of Cardiovascular Surgery, Mohamed VI University Hospital-Marrakech Morocco, between January 2006 and June 2016.

Data including age, diagnosis, weight, sex, primary PA banding procedure, early and late complications, early and late mortality rate, causes of death and follow-up period were extracted and analyzed.

### Surgical procedure

92% of patients were operated through a mini-sternotomy exposure (limited to the upper part of the sternum), for all patients we use 4 mm width nylon band and Trusler method: 20 mm + infant weight (kg) to achieve optimal PA banding.

The tightening of the band is determined using per-operative hemodynamic study (Catheters are inserted in both mean pulmonary artery (PA) and aorta to measure arterial pressures during the procedure). The PA pressure was reduced by 30 to 50% of systolic pressure with assessment of the patient's tolerance (Saturation, $ETCO_2$, Heart rate) (Figure 1).



***A*** ***B***

***Figure 1:*** *A: Catheters are inserted in both MPA and aorta to measure arterial pressures during the procedure. B: The tightening of the band is determined using per-operative hemodynamic study.*

In all of the patients arterial oxygen saturation was considered and most of them had the arterial oxygen saturation of more than 80% to 85% with FIO2 of 50%. When the ideal diameter was obtained, the band was fixed to the pulmonary artery trunk adventitia to prevent migration of the band.

The effectiveness of the banding is reassessed using trans-thoracic ultrasound cardiography in the ICU (Gradient through PA band) and then discharge.

## Results

The mean age was 9.4 months (2 months to 10 years) and 67,33% of patients were operated before the age of 6 months old with Down syndrome in 71% of them. The mean weight was 5.4 kg (2 to 12 kg). No sex difference in this study group (Males: 52%). 18.5% of patients were on Heart failure preoperatively. The type of cardiac defects are listed in table 1.

| Congenital Heart Disease | Percentage (Number) |
|---|---|
| Complete Atrioventricular Canal (CAVC) | 44.2% (73) |
| Ventricular septal defect (VSD) | 36.9% (61) |
| Double outlet Right ventricle (DORV) | 6% (10) |
| Single Ventricle | 4.2% (7) |
| Transposition of Great Arteries(TGA) | 6.6% (11) |
| Truncus Arteriosus | 1.8%(3) |

***Table 1:*** *Type of cardiac defects.*

Seventy-three patients had complete atrioventricular canal (CAVC) (44.2%) and 61 patients had ventricular septal defect (36.9%) with large VSD in 54 patients and multiple VSD in 7 patients.

Other cardiac anomalies were the double outlet right ventricle (DORV) (6%), transposition of great arteries (6.6%), single ventricular (4.2%) and Truncus Arteriosus (1.8%).

The mean indication for PAB was pulmonary hypertension in 65 patients (39%), low weight(less than 6kg) in 86 patients (52%) and complex heart disease in 25 patients (15%).

Using the invasive hemodynamic study the mean pulmonary arterial pressure (PAP) was lowered by 34.7% and systemic arterial pressure increased by 18%. The mean pre-band PAP was 62 mm Hg (55 - 90 mmhg) and the mean post-band PAP was 40.4 mm Hg (30 - 63 mmhg) on $FiO_2$ 50%.

We did additional procedures of PDA ligation in 30% of patients, coarctectomy in 1.5% of patients and Blalock Taussig shunt procedure in 1.8%. For 37% of patients the inotropic support (dopamine) was used during the procedure.

The mean ICU stay was 4.5 days (2 - 16 days). 17% patients had postoperative complications. There were 27 cases of postoperative atelectasia (16.3%) and 11 cases of the sepsis (6.6%) and 21 cases of prolonged intubation (intubation period more than 2 days) (12.7%). No case of bleeding and PA injury during operation were found. The in-hospital mortality was 15.7% (26 cases) and 11 cases of them died due to sepsis and others died due to heart failure.

Postoperative trans-thoracic ultrasound cardiography assessment (less than month) Performed for only 79 patients (47.8%) and the mean gradient across the banding was 33.9 mmhg (19.6 to 50 mmhg).

The post operation data and character of patients are shown in table 2.

| | |
|---|---|
| Mean ICU stay | 4.5 days (2 - 16 days) |
| Inotropic support | 37% of patients |
| Atelectasia | 29 cases (17.5%) |
| Sepsis | 11 cases (6.6%) |
| Mean mechanical ventilation duration | 16H (0H- 10days) |
| Postoperative mean gradient across the banding | 33,9 mmhg (19,6 to 50 mmhg) |

***Table 2:*** *The postoperative data and characters of patients.*

The mean follow-up period was 39 months. We noted three cases of loose band (1.8%) and two cases of PA bifurcation stenosis (1.2%). The banded children have recorded good weight gain with a mean pre-band weight of 5.4 kg (2 - 12 kg) and post-band weight of 8.6 kg (3 - 14 kg). Three patients (1.8%) died during follow up period (indeterminate cause).

Thirty six percent had complete repair in our unit after PAB of a mean interval of 25 months. The mean age of definitive repair was 34 months and the mean weight was 11 kg.

In definitive repair, only 3% of patients underwent pulmonary artery repairing with pericardial patch after PA de-banding and the rest of patients underwent just PA de-banding without any repair of pulmonary artery.

There were residual pulmonary gradient in 5% of patients after definitive repairing (without PA plasty) with a mean gradient of 35 mmHg.

## Discussion

We know that primary repair is the first choice to treat congenital heart defects [4,5]. PAB remains a valuable tool allowing palliative intervention in patients not conducive for immediate primary repair. Early primary repair may be more beneficial but PAB is still indicated with high interest mortality. If the definitive surgery had been undertaken at a younger age, the mortality could have been higher. We resorted to PA band in the interest of safety, and our results are relevant to developing centers with suboptimal infrastructure for the care of infants.

The mortality interval was not there and the results of definitive surgery were acceptable.

With improvement in infrastructure, we are also moving towards primary correction. However, the two-stage strategy has proven well for our patients and our policy is to avoid performing too many complete repairs of CHD on patients weighing less than 6 kg.

In our study the mortality rate of PA banding was 15.7%, mortality rate in other studies reported between 10% - 38% [4,5]. The reported mortality rate decreased from approximately 30% before 1980 to approximately 10% [4-6].

In our study, multivariate analysis demonstrated that no isolated variable including weight, Down syndrome, pulmonary hypertension and diagnosis were significant risk factors. But in some reports, the child's weight was detected as a significant risk factor for early death [2].

The complications of banding include distal migration of band and erosion of band in the PA lumen [2,5]. We had bifurcation stenosis in 1.2% of our patients, loose band in 1.8%, and we didn't have any erosion of band in the PA lumen and we also did not have bleeding and rupture of PA in our series.

Invasive monitoring of PAB ensures its efficacy, which was proved by post-operative ultrasound study. The advantages were the Objective criteria to decide the degree of tightness of the band in addition to heart rate, $SaO_2$ and $ETCO_2$, but the limits were at most times unverifiable with interfering parameters (systemic and pulmonary resistances, type of congenital heart defect, heart rate, heart contractility, mechanical ventilation and weight of the patient). The advantages of partial sternotomy are: fully expanded lungs, concomitant procedures, cosmetic advantage, reduced risk of scoliosis resulting from a neonatal thoracotomy.

Mean postoperative gradient through the band at 35 mmHg, Sreeram., *et al.* Mean PAP at 66 mmHg. Too tight can result Erosion or pseudoaneurysm of the MPA, valvular pulmonary stenosis, subaortic stenosis and loose band can result persistence of heart failure, ineffective protection of pulmonary circulation [7,8].

The management of PA band at the definitive repair stage was mostly only debanding. Only 3% of patients underwent pulmonary artery plasty after PA de-banding.

The financial and psychological stress of two operations, we believe was counter balanced by the well-being gained. Our unit is shared by adult and congenital cardiovascular surgery program with limited infrastructure and resources. Primary repairs in low-weight newborns and infants remain challenging.

## Conclusion

We believe that PA banding confers good palliative therapy to patients with certain CHD in units with limited resources for pediatric post-operative cardiac care. There is no absolute and reliable scientific technique that establishes the needed band length. Per-operative hemodynamic study is a reasonable technical alternative. Considering the high morbi-mortality of PAB, it could be cautious to improve our infrastructure and human resources for early complete repair.

### What is already know on this topic

Pulmonary artery binding has a role in treatment of congenital heart anomalies.

### What this study adds

Our results will support the need to improve infrastructure and human resources in developing countries for primary repair of intracardiac anomalies in small infants.

## Disclosures

The authors report no competing interests about this article.

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